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(71) Applicant(s)
Hitachi Ltd

(Incorporated in Japan)

6 Kanda Surugadai 4-chome, Chiyoda-ku, Tokyo 100-101, Japan

(72) Inventor(s)
Kazuhito Koyama
Shigehisa Sugita

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GB 1354073 A **GB 1152008 A** **GB 0835815 A**

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(72) cont
Shinya Marushima
Yuji Makino
Kazuhiro Gonda

(74) Agent and/or Address for Service
Mewburn Ellis
York House, 23 Kingsway, LONDON, WC2B 6HP, United Kingdom

(54) Fuel reforming apparatus and electric power generating system

(57) A cylindrical fuel reforming apparatus covered with an insulating layer 16 comprises a fuel flow passage 1 and a catalyst bed 3. A cooling jacket 10 is supplied with air. Gas, preferably methane, from inlet pipe 6 and air 7 are partially combusted and steam from pipe 11 is swirled by a swirling device 22 upstream of the catalyst. The resulting hydrogen enriched unburned gas 13 is burned in a gas turbine which drives a electric power generator. Exhaust gas from burner is delivered to an exhaust heat recovery boiler containing water. Steam is thus generated and fed back to the reformer, thereby enabling heat to be recovered.

FIG. 1

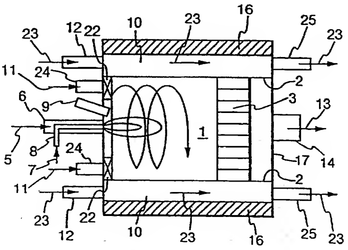

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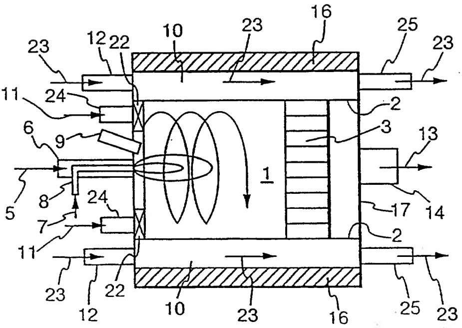
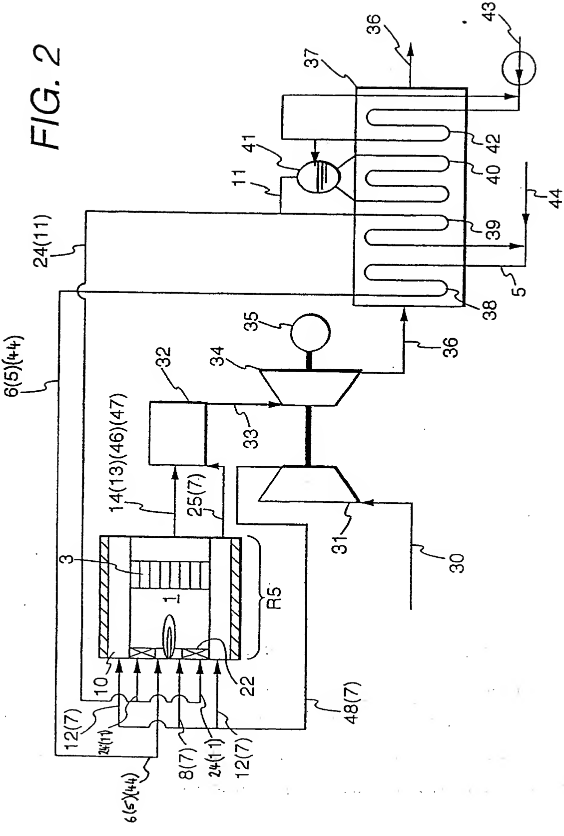
FIG. 1





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14(13)(46)(47)
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12(7)
24(11)
48(7)
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6(5)(44)
8(7)
24(11)
12(7)

FIG. 2

TITLE OF THE INVENTION

FUEL REFORMING APPARATUS AND ELECTRIC POWER GENERATING SYSTEM HAVING THE SAME

BACKGROUND OF THE INVENTION

The present invention relates to a fuel reforming apparatus and a electric power generating system having the fuel reforming apparatus, and more particularly to a fuel reforming apparatus of direct heat exchange type suitable for a gas turbine electric power generating system and a electric power generating system having the fuel reforming apparatus.

A fuel reforming apparatus of indirect heat exchange type, a fuel reforming apparatus of direct heat exchange type and the like have been known as fuel reforming apparatuses for reforming a raw fuel such as a hydrocarbon into a hydrogen enriched gas.

Among them, the fuel reforming apparatus of indirect heat exchange type comprises a reactor pipe having a reforming catalyst and a burner for giving heat to the reactor pipe, in which a raw fuel entered into the reactor pipe through one end of the reactor pipe is reformed into a hydrogen enriched gas using the reforming catalyst filled inside of the reactor pipe while the reactor pipe is being heated with the burned gas from the burner.

On the other hand, the fuel reforming apparatus of direct heat exchange type comprises a fuel flow passage having a

reforming catalyst inside, in which a part of a raw fuel is partially oxidized (burned) with air inside the flow passage, and the obtained high temperature gas to be reformed is reformed into a hydrogen enriched gas using a reforming catalyst bed. The fuel reforming apparatus of direct heat exchange type is used in the field of chemical industry.

Gas turbine electric power generating systems having a fuel reforming apparatus are disclosed in, for example, Japanese Patent Application Laid-Open No.2-286835 (1990), Japanese Patent Application Laid-Open No.5-332166 (1993), Japanese Patent Application Laid-Open No.5-332167 (1993).

Since the fuel reforming apparatus of indirect heat exchange type described above has the burner for heating the reactor pipe, the size of the apparatus becomes large. Further, if the exhaust gas of the turbine is used for the heat source, it is difficult to obtain the reforming temperature of approximately 700°C required for the reforming reaction. In other words, taking the efficiency into consideration the exhaust gas temperature of the gas turbine is generally set to nearly 600°C in a highest case and around 500°C in a common case. Therefore, it is difficult to obtain the reforming temperature of approximately 700°C required for the reforming reaction.

In these points, the fuel reforming apparatus of direct heat exchange type is small in size since a part of the raw fuel is partially oxidized (burned) and the sufficiently high

reforming temperature required for the reforming reaction can be obtained. Therefore, the fuel reforming apparatus of direct heat exchange type is better than the fuel reforming apparatus of indirect heat exchange type.

The inventors tried to apply the fuel reforming apparatus of direct heat exchange type to a gas turbine electric power generating system, but the following problem are revealed. That is, in the fuel reforming apparatus of direct heat exchange type, the fuel flow passage performing the partial oxidization (burning) is formed of firebricks, and the heat load fluctuation applied to the firebricks is small in an fuel reforming apparatus in the field of chemical industry which is used for a long period under a constant operating condition. Therefore, cracks hardly occur in the firebricks. On the other hand, the heat load fluctuation applied to the firebricks is large in a gas turbine electric power generating system, cracks are apt to occur in the firebricks. Therefore, if the conventional fuel reforming apparatus of direct heat exchange type is directly applied to a gas turbine electric power generating system, there is a possibility to cause cracks in the firebricks. On addition to this, there is a possibility to cause a secondary failure by fractions of the broken firebrick. The disclosed gas turbine electric power generating system described above employs a fuel reforming apparatus of indirect heat exchange type.

SUMMARY OF THE INVENTION

The present invention has been derived from solving the above problems, and the object of the present invention is to provide a highly reliable fuel reforming apparatus which can be applied to a gas turbine electric power generating system having a large load fluctuation. At the same time, the object of the present invention is to provide a highly reliable electric power generating system with the fuel reforming apparatus.

In order to obtain a fuel reforming apparatus capable of attaining the above object, according to the present invention, a fuel reforming apparatus is constructed as follows.

A fuel reforming apparatus comprises a first chamber having a reforming catalyst bed inside; a second chamber for introducing a first medium for cooling the first chamber into the first chamber, the second chamber being arranged adjacent to the first chamber, wherein the apparatus additionally comprises swirling means for giving a swirl to a cooling medium supplied to the first chamber, the swirling means being provided upstream of the reforming catalyst bed.

In order to obtain an electric power generating system capable of attaining the object described above, according to the present invention, an electric power generating system is constructed as follows.

An electric power generating system comprises a

burner for obtaining a burned gas by burning a fuel, a turbine driven with the burned gas obtained in the burner, and an exhaust heat recovery boiler for generating steam using the exhaust gas exhausted from the turbine, which system further comprises a fuel reforming apparatus as described above, said cooling medium being the steam obtained from the exhaust heat recovery boiler and obtaining the fuel supplied to the burner.

According to a fuel reforming apparatus of the present invention, cooling medium of air is introduced into the cooling jacket to cool the fuel flow passage from the outside. Further, steam is supplied to the fuel flow passage through a swirl means. The supplied steam widely expands inside the fuel flow passage to cool the fuel flow passage from the inside. By doing so, the fuel flow passage exposed to a high temperature reformed gas can be protected from the high temperature reformed gas. The steam is mixed with the reformed gas. Therefore, the temperature of the reformed gas flowing into the reforming catalyst bed is adjusted to a temperature suitable for reforming in the reforming catalyst bed.

According to the electric power generating system described above, the fuel reforming apparatus is cooled by the steam generated in the exhaust heat recovering boiler or the compressed air. By doing so, even if fluctuation in the thermal load occurs due to the load fluctuation of the gas turbine, fuel gas to be supplied to the burner can

be obtained while the fuel reforming apparatus is being protected against the heat.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of an embodiment of a fuel reforming apparatus in accordance with the present invention being taken on the plane including the axial line of the fuel reforming apparatus.

FIG. 2 is a system diagram showing an embodiment of an electric power generating plant having the fuel reforming apparatus of FIG. 1 in accordance with the present invention.

DESCRIPTION OF EMBODIMENTS

The present invention will be described in detail below, referring to the accompanying drawings.

FIG. 1 is a cross-sectional view of an embodiment of a fuel reforming apparatus in accordance with the present invention being taken on the plane including the axial line of the fuel reforming apparatus.

A cylindrical fuel reforming apparatus covered with a thermal insulating layer 16 comprises a fuel flow passage 1 contoured by a cylindrical contour wall 2 in its central axial direction and a reforming catalyst bed 3 in the middle of the flow passage for reforming gas to be reformed flowing from the upstream of the fuel flow passage 1 into a proper reformed gas. A cooling jacket 10

is arranged around the fuel flow passage 1 so as to surround the fuel flow passage 1 and to be supplied with air 23 for cooling the cylindrical contour wall 2.

Wherein, the word "contour" means to determine a contour or a shape of a substance, and the words "contour wall" mean a wall to determine a contour or a shape of a substance.

The thermal insulating layer 16 has a role for shielding heat radiated from the fuel reforming apparatus, and is constructed with a heat insulator made of glass wool or ceramic wool having a small thermal conductivity. The reforming catalyst bed 3 is made of a nickel alloy having a better reforming characteristic to hydrocarbon and being low in cost.

A fuel supply pipe 6, through which a mixed gas 5 obtained by mixing a fuel such as hydrocarbon with steam in a proper ratio is supplied to the fuel flow passage 1 from the outside, is connected nearly to the central portion of an end surface 4 in the upstream side of the fuel reforming apparatus, and an air supply pipe 8 for supplying air 7 from the outside into the fuel flow passage 1 is arranged inside the fuel supply pipe 6 nearly on its center axis. A plurality of steam supply pipes 24 for supplying the steam 11 from the outside into the fuel flow passage 1 arranged around the fuel supplying pipe 6, and a plurality of cooling medium supply pipes 12 for supplying air 23 from the outside into the

cooling jacket 10 arranged in the peripheral direction of the fuel reforming apparatus along the cooling jacket 10 are connected to the end surface 4 in the upstream side. The reference character 9 is a spark plug for igniting the gas supplied into the fuel flow passage 1.

A fuel outlet pipe 14 for exhausting hydrogen enriched gas 13 obtained by being reformed with the reforming catalyst bed 3 is connected to nearly the central portion of the end surface 17 in the down stream side of the fuel reforming apparatus. A cooling medium outlet pipe 25 for supplying the air 23 introduced into the cooling jacket 10 to the outside arranged in the peripheral direction of the fuel reforming apparatus along the cooling jacket 10 is connected to the end surface 17 in the downstream side.

In order to give swirl to the steam 11 supplied in the fuel flow passage 1 through the plurality of steam supply pipes 24, a swirl device 22 arranged so as to surround circularly the fuel supply pipe 6 is provided in the upstream side of the reforming catalyst bed 3, that is, the end portion of the fuel flow passage 1 (the end surface 4 in the upstream side).

The fuel reforming apparatus according to the present invention is constructed as described above, and operates as follows.

A mixing gas 5 mixed a fuel such as hydrocarbon (methane in this embodiment) and steam in a proper ratio is supplied to the fuel flow passage 1 through the fuel supply pipe 6, and air 7 is supplied to the fuel flow passage 1 through the air supply pipe 8. The mixed gas 5 and the air supplied to the fuel flow passage 1 are ignited with the spark plug 9 to be burned diffusely. Therein, since the flow rate of the air 7 supplied to the fuel flow passage 1 through the air supply pipe 8 is as much as an amount to burn approximately 20% of the supplied mixed gas 5 (the fuel of methane), the mixed gas is partially oxidized (partial combustion) and a high temperature gas containing unburned gas to be reformed can be obtained. In this embodiment, the diffuse combustion having a wide stable combustion range is employed as the combustion method.

Although the mixed gas 5 supplied to the fuel flow passage 1 through the fuel supply pipe 6 is obtained by mixing the fuel such as hydrocarbon and the steam in a proper ratio in advance, the timing of the mixing may be at the time before supplying to the fuel supply pipe 6, or the fuel such as hydrocarbon and the steam may be separately supplied to the fuel supply pipe 6.

Steam 11 is supplied to the fuel flow passage 1 through the steam supply pipe 24. At this time, a swirl is given to the steam 11 by the swirl device 22 provided in the upstream side of the reforming catalyst bed 3, that is, the end portion of the fuel flow passage 1 (the end surface 4 in the upstream side), the steam is expanded widely. The steam 11 expanded widely cools the cylindrical contour wall 2 exposed to the high temperature gas to be reformed from the inside, and at the same time mixes with the high temperature gas to be reformed containing unburned gas obtained by the combustion to adjust the high temperature gas to be reformed containing unburned gas to a temperature suitable for entering the reforming catalyst bed 3, that is, a temperature suitable for the reforming.

On the other hand, air 23 is supplied into the cooling jacket 10 through the cooling medium supply pipe 12. The air 23 supplied to the cooling jacket 10 cools the cylindrical contour wall 2 exposed to the high temperature gas to be reformed obtained through the combustion described above from the outside of the cylindrical contour wall. The air 23 supplied into the cooling jacket 10 after cooling is supplied to the outside through the cooling medium outlet pipe 25.

The gas to be reformed adjusted to a temperature suitable for entering the reforming catalyst bed 3, that is, a temperature suitable for the reforming is reformed to a

hydrogen enriched gas 13 by the reforming catalyst bed 3 and then supplied to an external apparatus through the fuel outlet pipe 14.

In the reforming catalyst bed 3, a chemical reaction expressed by the following equation occurs to reform the gas to be reformed to a hydrogen enriched gas 13. This reforming reaction is called as steam reforming reaction of methane which is an endothermic chemical reaction to change a mixed gas of methane and steam into a hydrogen enriched gas.

$$CH_4+sH_2O \rightarrow hH_2+c_1CO+c_2CO_2-\Delta Q \quad \ldots(1)$$

where, s, h, c_1, c_2 are constants and ΔQ is reaction heat.

According to the embodiment, since the cooling jacket 10 is arranged so as to surround the fuel flow passage 1 and air 23 is supplied into the cooling jacket 10, the cylindrical contour wall 2 is cooled by the air 23 supplied to the cooling jacket 10 from the outside.

Since the swirl device 22 is provided in the upstream side of the reforming catalyst bed 3, that is, the end portion of the fuel flow passage 1 (the end surface 4 in the upstream side) and a swirl is given to the steam 11 supplied into the fuel flow passage 1 through the steam supply pipe 24 to expand the steam 11 inside the fuel flow passage 1 widely, the cylindrical contour wall 2 is cooled by the steam 11 form the inside. By doing so, the cylindrical contour wall 2 exposed to the high temperature gas to be reformed obtained

by the combustion is protected by being cooled both from the inside and from the outside. Therefore, the reliability of the reforming apparatus to high temperature is improved.

An embodiment of an electric power generating system having the aforementioned fuel reforming apparatus will be described below.

FIG.2 is a system diagram showing an embodiment of an electric power generating plant having the fuel reforming apparatus of FIG.1 in accordance with the present invention. This embodiment of the electric power generating system can be roughly classified into a gas turbine system, an exhaust heat recovering system and a fuel reforming system.

The gas turbine system comprises a burner 32 for obtaining high temperature combustion gas 33 by burning combustion air 30 compressed by an air compressor 31 supplied through a fuel reforming system to be described later and fuel, and a gas turbine 34 driven by the high temperature combustion gas 33 obtained in the burner 32 and driving a electric power generator 35 directly coupling to the gas turbine 34.

The exhaust heat recovering boiler system comprises an exhaust heat recovering boiler 37 for obtaining steam by exchanging heat between the exhaust gas 36 exhausted from the gas turbine 34 and feed water. In the exhaust heat recovering boiler 37, a mixed gas heater 38, a steam heater 39, an evaporator 40 (drum 41), an economizer 42 are arranged from the high pressure side of the exhaust gas 36 in this order.

The fuel reforming system comprises a fuel reforming apparatus R5 for obtaining a gas to be reformed by burning a mixed gas 5 supplied through a fuel supply pipe 6 and air 7 supplied from an air compressor 31 through an air supply pipe 8 and for obtaining a fuel gas 46 by reforming the gas to be

reformed with a reforming catalyst bed 3. The reference character 12 is a cooling medium supply pipe for supplying air 7 to the cooling jacket 10 and one end of the cooling medium supply pipe 12 is connected to the cooling jacket 10, the reference character 24 is a steam supply pipe for supplying steam 11 into the fuel flow passage 1, the reference character 14 is a fuel outlet pipe for supplying the fuel gas 46 obtained by the fuel reforming apparatus R1 to the burner 32, and the reference character 25 is a cooling medium outlet pipe for supplying air 7 supplied in the cooling jacket 10 to the burner 32.

The electric power generating system according to the present invention is constructed as described above, and operates as follows.

At starting of operation, a raw fuel 44 is supplied to the fuel flow passage 1 of the fuel reforming apparatus R5 through the fuel supply pipe 6. At the same time, the air 7 compressed by the air compressor 31 is supplied to the fuel flow passage 1 through a main air pipe 48 and the air supply pipe 8 and air 7 is supplied to the cooling jacket 10 through the main air pipe 48 and the cooling medium supply pipe 12. The supplied raw fuel 44 and the supplied air 7 supplied into the fuel flow passage 1 are ignited by a spark plug (not shown) and burned to be changed to an unburned gas 47 having a temperature around several hundreds degrees. The unburned gas 47 obtained in such a manner flows inside the fuel flow

passage toward the downstream, and is supplied to the burner 32 through the fuel outlet pipe 14. At this time, the unburned gas 47 heats the reforming catalyst bed 3 installed inside the fuel flow passage 1. The air 7 supplied into the cooling jacket 10 cools the fuel flow passage 1 from the outside, and is supplied to the burner 32 through the cooling medium outlet pipe 25.

The unburned gas 47 and the air 7 supplied to the burner 32 are mixed and burned. The combustion produces a high temperature burned gas 33, and the obtained burned gas 33 drives the gas turbine 34 and exhausted from the gas turbine 34 as an exhaust gas after driving the gas turbine 34. The electric power generator 35 directly coupled to the gas turbine 34 is driven by the gas turbine 34.

The exhaust gas 36 exhausted from the gas turbine 34 is supplied to the exhaust heat recovering boiler 37 to exchange the heat with the feed water 43. The feed water 43 is supplied to the economizer 42 by a pump to be preheated by the low pressure exhaust gas 36. The preheated feed water is supplied to the evaporator 40 (drum 41) and changed to steam 11 by being heated with the high pressure exhaust gas 36. The steam 11 is supplied to the fuel flow passage 1 through the steam supply pipe 24 and the swirl device 22.

The steam 11 is also branched from the cooling medium supply pipe 12 and supplied to a steam heater 39 to be heated by the higher pressure exhaust gas 36. The heated steam 11 is

mixed with the raw fuel 44 (methane is employed in this embodiment) and supplied to a mixed gas heater 38 to be heated by the highest pressure exhaust gas 36. The mixed gas 5 obtained in such a manner is supplied to the fuel flow passage 1 of the fuel reforming apparatus R5 through the fuel supply pipe 6.

The mixed gas 5 supplied to the fuel flow passage 1 is diffuse-burned (partially oxidized) with the air 7 supplied to the fuel flow passage through the air supply pipe 8. The high temperature gas to be reformed obtained by the diffuse combustion is mixed with the steam 11 supplied to the fuel flow passage through the swirl device 22, and adjusted to a temperature suitable for entering the reforming catalyst bed 3, that is, a temperature suitable for the reforming and then allowed to flow into the reforming catalyst bed 3. The gas to be reformed is reformed by the reforming catalyst bed 3 to be changed to the hydrogen enriched gas 13. The hydrogen enriched gas 13 obtained in such a manner is supplied to the burner 32 through the fuel outlet pipe 14. After this time, the hydrogen enriched gas 13 is supplied to the burner 32 as the fuel gas.

According to the embodiment, since the air 7 compressed by the air compressor 31 is supplied to the cooling jacket 10 of the fuel reforming apparatus R5 through the main air pipe 48 and the cooling medium supply pipe 12, the fuel flow passage 1 of the fuel reforming apparatus R5 exposed to the

high temperature gas is cooled by the steam 11 from the outside. Further, since the steam 11 obtained by the exhaust heat recovering boiler 37 is supplied to the fuel floe passage 1 through the steam supply pipe 24 and the swirl device 22, the fuel flow passage 1 exposed to the high temperature gas is cooled from the inside. Thereby, the fuel reforming apparatus R5 can be protected from high temperature heat even if the heat load is changed by the load fluctuation of the gas turbine 34. Therefore, the reliability of the electric power generating system can be improved.

Further, according to the embodiment, the air supplied from the air compressor 31 to the burner 32 is supplied through the cooling jacket 10 of the fuel reforming apparatus R6, the air is supplied after cooling the fuel reforming apparatus R5. Thereby, the fuel reforming apparatus R5 is cooled even when the system is starting up. Therefore, the reliability of the electric power generating system can be improved.

Further, according to the embodiment, since the mixed gas heater 38 and the steam heater 39 are provided in the exhaust heat recovering boiler 37 to perform heat exchange of the mixed gas 5 supplied to the fuel reforming apparatus R1 and the exhaust gas 36 exhausted from the gas turbine 34, the heat in the exhaust gas 36 can be effectively recovered. Therefore, the thermal efficiency of the electric power generating system can be improved.

Furthermore, according to the embodiment, since the main air pipe 48 for supplying the air 7 compressed by the air compressor 31 to the reforming system and the air supply pipe 8 and the cooling medium supply pipe 12 are connecting to the main air pipe 48, the air 7 compressed by the air compressor 31 is supplied to the fuel flow passage 1 through the main air pipe 48 and the air supply pipe 8 and supplied into the cooling jacket 10 through the main air pipe 48 and the cooling medium supply pipe 12. Further, since the cooling medium outlet pipe 25 is connected to the burner 32, the air 7 supplied into the cooling jacket 10 is supplied to the burner 32 through the cooling medium outlet pipe 25. Thereby, a separate air supply apparatus for supplying air to the fuel reforming apparatus R5 is not required. Furthermore, since the fuel reforming apparatus R5 and the burner 32 are connected in series and it is possible to construct the fuel reforming apparatus R5 and the burner 32 as a unit, the electric power generating system can be made simple. Therefore, the cost of the electric power generating system can be decreased. This construction of electric power generating system is effective to a co-generation system built in a narrow installing area such as in a factory. This construction of electric power generating system may be also applied to a combined plant.

Further, according to the embodiment, since a large amount of steam is supplied to the fuel reforming apparatus

R5 by supplying the mixed gas 5 containing the steam 11 to the raw fuel 44 and further by supplying the steam 11 into the fuel flow passage 1 to mix with the gas to be reformed, the fuel gas 46 supplied to the burner 32 from the fuel reforming apparatus R5 contains steam. By doing so, the combustion temperature in the burner 32 is suppressed by the steam contained in the fuel gas 46, and consequently the yield amount of NO_x can be decreased, that is, the amount of NO_x can be lowered. Therefore, the reliability of the electric power generating system can be improved.

By lowering NO_x yield, an apparatus such as NO_x removal system is not required, and running cost required for NO_x removal such as cost for aqueous ammonia is decreased, and the construction of the electric power generating system can be simplified. Therefore, the cost of the electric power generating system can be decreased.

Further, according to the embodiment, since the fuel reforming apparatus R5 reforms the raw fuel to the fuel gas 46 containing hydrogen, the burning capability (combustion speed, combustion range) in the burner 32 supplied with the fuel gas 46 is improved. Thereby, since it is possible to add further steam to the burner 32, the output power or the efficiency of the electric power generating system can be improved and the heat-electricity ratio (ratio of thermal power output to electric power output) of the electric power

generating system can be widely changed. Therefore, the operability of the electric power generating system can be improved.

According to the present invention, since the cooling jacket is arranged adjacent to the fuel flow passage and a cooling medium for cooling the fuel flow passage is introduced into the cooling jacket, the fuel flow passage can be protected from high temperature even if the heat load changes due to the load fluctuation of the gas turbine.

Therefore, it is possible to provide a fuel reforming apparatus having a high reliability which can be applied to a gas turbine electric power generating system. Further, it is possible to provide a electric power generating system having a high reliability with the above fuel reforming apparatus.

CLAIMS

1. A fuel reforming apparatus comprising a first chamber having a reforming catalyst bed inside, a second chamber arranged adjacent to said first chamber having a first medium for cooling said first chamber, and where a second medium is supplied to said first chamber, wherein swirling means for giving a swirl to said second medium are provided, said swirling means being upstream of said reforming catalyst bed.

2. An electric power generating system comprising a burner for obtaining a burned gas by burning a fuel, a turbine driven with the burned gas obtained in said burner, and an exhaust heat recovery boiler for generating steam using the exhaust gas exhausted from said turbine, which further comprises:

a fuel reforming apparatus according to claim 1, said second medium being said steam generated by said exhaust heat recovery boiler.

3. A fuel reforming apparatus substantially as herein described with reference to and as shown in figure 1 of the accompanying drawings.

4. An electrical power generating system having a fuel reforming apparatus according to claim 3.

5. A method of reforming fuel comprising the use of apparatus according to claim 1 or 3.

The Patent Office

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Application No: GB 9619546.6
Claims searched: 1-5

Examiner: Dr J Houlihan
Date of search: 14 January 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): C5E (EAP, EAQ EAS, EAT)

Int Cl (Ed.6): C01B 3/26, 3/38

Other: ONLINE: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 1354073	(METALLGESELLSCHAFT AKTIENGESELLSCHAFT) page 2 lines 115-120; page 4 lines 23-27 & 72-88; Claims 3 & 14; Figure 1	1 & 5
A	GB 1152008	(THE GAS COUNCIL) page 2 lines 38-53	
Y	GB 0835815	(N.V. De BATAAFSCHE PETROLEUM MAATSCHAPPIJ) page 2 lines 94-124; page 3 lines 8-17; Figure 1	1 & 5

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